Bond Enthalpy calculations

QUESTIONS: Carry out the following Bond Enthalpy calculations
For additional information please use the values provided in the table below

Bond	ΔH (kJ mol^{-1})	Bond	ΔH (kJ mol^{-1})
H–H	436	C–H	412
C–C	348	N–H	388
C=C	612	O–H	463
C≡C	837	Cl–H	431
N–N	163	C=O	743
N=N	409	C–N	305
N≡N	944	C=N	613
O–O	146	N≡C	890
O=O	496	C–Cl	338
Cl–Cl	242	Si–O	374

reference: 2007, International Baccalaureate Organization Chemistry Data booklet

1) a) The equation for the combustion of propan-1-ol is:

$$CH_3CH_2CH_2OH(g) + 4½O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g) \quad \Delta_r H = -2010 \text{ kJ mol}^{-1}$$

Calculate the bond enthalpy for the C=O bond, using the enthalpy of the reaction above and the bond enthalpy data

b) Define bond enthalpy and explain why the bond enthalpy value calculated for C=O is higher than the C–O bond enthalpy.

2) Complete combustion of methanol can be represented by the following chemical equation: Use the bond enthalpies to calculate $\Delta_r H$ for this reaction.

$$2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$$

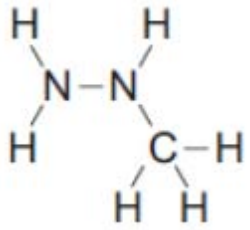
3) The equation for the combustion of ethanol is: Calculate the bond enthalpy for the O–H bond

$$CH_3CH_2OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)\ \Delta_r H° = -1379\ \text{kJ mol}^{-1}$$

4) Calculate the enthalpy change for the reaction below using the bond enthalpy data in the table.

$$CH_3Cl(g) + NH_3(g) \rightarrow CH_3NH_2(g) + HCl(g)$$

5) Methylhydrazine, $N_2H_3CH_3$, can be used as a fuel. The structural formula for methylhydrazine is



i) Define the term bond enthalpy.

ii) Use the bond enthalpies given in the table below to calculate the energy released when one mole of methylhydrazine vapour is burned.

$$N_2H_3CH_3(g) + 2½O_2(g) \rightarrow CO_2(g) + N_2(g) + 3H_2O(g)$$

6) Calculate the enthalpy of formation of water in the gas state, $\Delta_f H°(H_2O, g)$

7) Carbon monoxide is reacted with steam to produce hydrogen gas.

$$CO(g) + H_2O(g) \rightarrow H_2(g) + CO_2(g) \quad \Delta_r H = -41.2 \text{ kJ mol}^{-1}$$

(i) The bond enthalpies for the carbon to oxygen bonds in CO_2 and CO are different. Use the bond enthalpies and the enthalpy of the reaction to calculate the bond enthalpy of the carbon to oxygen bond in CO. Why are bond enthalpy values always positive? Explain the difference between the following bond enthalpies.

(ii) Why are bond enthalpy values always positive?

(iii) Explain the difference between the C – O and C = O enthalpies

8) A fuel cell, such as that used on a space-craft, is similar to a battery. An example is the fuel cell that 'burns' hydrogen and oxygen to produce water and energy.

The overall equation for the reaction is

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)\ \Delta rH^\circ = -572\ kJ\ mol^{-1}$$

a) If the water produced is in the gas phase the equation for the reaction is Use the bond enthalpies to calculate $\Delta_r H^\circ$ for this reaction.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

b) Write an equation for which the enthalpy change is equal to $\Delta_{vap}H^\circ (H_2O)$.

c) By considering the nature of the reaction in part (b), describe why it is an endothermic change. Using the information in parts above, calculate the value of $\Delta_{vap}H^\circ (H_2O)$.

d) Using the information in parts (a) to (c) above, calculate the value of $\Delta_{vap}H^\circ (H_2O)$.